

Suboptimal diabetic control and psychological burden after the triple disaster in Japan: the Fukushima Health Management Survey

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ABSTRACT

Introduction A triple disaster struck eastern Japan in March 2011. We investigated the psychological distress and post-traumatic stress disorder (PTSD) symptoms caused by the disaster in people without or with diabetes mellitus.

Research design and methods This cross-sectional analysis examined the 16 097 evacuees (1820 (11.3%) with and 14 277 (88.7%) without diabetes mellitus) included in the Fukushima Health Management Survey. Non-specific mental health distress was assessed using the Kessler-6 Scale, and traumatic symptoms were evaluated using the PTSD Checklist. Logistic regression analyses were used to estimate the OR and 95% CI associated with symptoms, adjusted for diabetes-related and disaster-related factors.

Results In the age-adjusted and sex-adjusted logistic models, suboptimal diabetic control (hemoglobin A1c (HbA1c) $\geq 7\%$) was associated with both psychological distress and possible PTSD. In the same models, current smoking, evacuation, and sleep dissatisfaction were associated with psychological distress and possible PTSD. In the multivariate-adjusted logistic models, HbA1c $\geq 7\%$ was associated with psychological distress, independent of job change, evacuation, or sleep dissatisfaction.

Conclusion After the triple disaster, non-specific mental health distress was associated with suboptimal diabetic control. Thus, patients with diabetes, especially those with suboptimal diabetic control, may be vulnerable to postdisaster psychological burden.

INTRODUCTION

In March 2011, a triple disaster, namely the Great East Japan Earthquake, tsunami, and subsequent Fukushima Daiichi nuclear disaster, occurred in Japan. Together, these events caused a devastating catastrophe in East Japan, mostly affecting residents in the local area. Due to radiation release concerns, residents were forced to evacuate and suffered long-lasting psychosocial burden. Shortly

Significance of this study

What is already known about this subject?

- People with diabetes have been suggested to be more susceptible to psychological reactions than those without diabetes.

What are the new findings?

- Presence or absence of diabetes mellitus was not significantly associated with non-specific mental health distress, assessed by Kessler-6 Scale, and possible post-traumatic stress disorder (PTSD) symptoms, assessed by the PTSD Checklist, among the evacuees in the Fukushima Health Management Survey.
- Diabetes mellitus with hemoglobin A1c $< 7\%$ was not associated with psychological distress or possible PTSD.
- Diabetes mellitus with hemoglobin A1c $\geq 7\%$ was associated with psychological distress, even after multivariate adjustment.

How might these results change the focus of research or clinical practice?

- Assessment and management of postdisaster psychological burden should be considered in patients with diabetes, especially those with suboptimal diabetic control.

after the disaster, the Fukushima Health Management Survey was conducted to investigate the effects of the long-term, low-dose radiation exposure caused by the accident and to assess the physical and mental well-being of evacuees and non-evacuees.^{1 2} This study included the basic survey, which estimated radiation exposure, and the detailed health surveys, which included the comprehensive health check and the mental health and lifestyle survey.^{1 2}

Among the potential health concerns that arose after the triple disaster were severe mental health problems, especially among the evacuees.³ The variety of psychosocial reactions were summarized as post-traumatic stress response, chronic anxiety and guilt, ambiguous loss, family and community separation, and stigmatization.³ People with diabetes have been suggested to be more susceptible to psychological reactions than those without diabetes.⁴ The prevalence of serious psychological distress (≥ 13 on the Kessler-6 (K6) Scale) among people with diabetes (7.6%) is approximately twice as high as that in the general US adult population (3.6%; unadjusted OR, 2.09; 95% CI 1.87 to 2.34)⁵; however, the association is attenuated by adjusting for potential confounding factors (adjusted OR, 1.12; 95% CI 0.99 to 1.27). Nakaya *et al*⁶ reported that, in Japan, serious psychological distress is also more prevalent among people with diabetes than among those without diabetes (7.9% vs 5.3%; multivariate OR, 1.3; 95% CI 1.2 to 1.5; $p < 0.01$). Post-traumatic stress disorder (PTSD) is also known to be common among people with diabetes.^{4,7} However, the prevalence of psychological distress and PTSD after the 2011 triple disaster has not been elucidated in people with diabetes. Therefore, this study evaluated the psychological distress (ie, non-specific mental health distress and PTSD symptoms) in people without or with diabetes among the postdisaster evacuees or non-evacuees included in the Fukushima Health Management Survey.

RESEARCH DESIGN AND METHODS

Study design and population

This cross-sectional study was part of the Fukushima Health Management Survey, which targeted 123 314 people aged 40–74 years at the time of the earthquake and were officially registered as being from 13 administrative districts (villages, towns, and cities) where included the evacuation zone.^{2,8} The administrative districts have residents in the evacuation zone and in the non-evacuation zone. The Fukushima Health Management Survey includes four detailed annual surveys: thyroid ultrasound examination, comprehensive health check, mental health and lifestyle survey, and pregnancy and birth survey.² In this study, we employed participants who underwent the medical health check ($n=33\,493$) and those who received the mental health survey ($n=37\,858$) at 2011 baseline period (online supplemental figure S1). Because both surveys were too detailed and time-consuming, collections were not made on the same occasions. The baseline period in the comprehensive health check was from July 2011 to March 2012 and in the mental health and lifestyle survey was from January 2012 to November 2012. Intervals are crucial to interpret the associations between medical health and mental health measurements. We considered the time performed after the disaster and the order of measurement of the two surveys. As shown in online supplemental figure S2, we divided the participants in the two surveys by intervals

into within 1 month, 2 months, and over 2 months. Since hemoglobin A1c (HbA1c) is considered to be strongly correlated with mean glucose level over time at week 8 or week 12, compared with week 4,⁹ we evaluated the association mainly in those participants whose medical and mental assessments were obtained within the 2-month period. Among 20 701 who underwent both surveys, 16 097 fulfilled the variables required for inclusion in the full analysis set (online supplemental figure S1). To minimize the effects of order of the two surveys, we divided the participants into two groups: a medical health survey to mental health survey group and a mental health survey to medical health survey group. All participants provided written informed consent.

Mental health assessment

To assess participants' mental health status, we used the K6 Scale¹⁰ and the PTSD Checklist - Stressor-Specific Version (PCL-S).¹¹ The K6 Scale, used to measure non-specific mental health distress, asked participants if they had experienced any of the following six symptoms during the preceding 30 days: 'feeling so sad that nothing could cheer you up', 'feeling nervous', 'feeling hopeless', 'feeling restless or fidgety', 'feeling everything was an effort', and 'feeling worthless'. Each question was scored using a 5-point Likert-type scale from 0 to 4, with higher scores indicative of poorer mental health, with the total score ranging from 0 to 24. The Japanese version of the K6 Scale has been validated.^{12,13} Non-specific mental health distress was defined as a K6 score ≥ 13 .¹⁰ The PCL-S, used to measure traumatic symptoms caused by experience of the triple disaster, is a 17-item, self-reported measure. Each item was scored from 1 to 5, corresponding to 'not at all', 'a little bit', 'moderately', 'quite a bit', or 'extremely'. We classified participants as probably having PTSD if their PCL-S total score was ≥ 44 .¹¹ The Japanese version of the PCL-S was previously validated in the Fukushima Health Management Survey.¹⁴

Diabetes-related and disaster-related variables

General participant characteristics and diabetes-related or disaster-related variables were assessed using a self-reported questionnaire. Smoking status was classified into three categories: current, former, and never. Drinking status was similarly classified: non-drinker, light to moderate drinker (ethanol < 44 g/day) or heavy drinker (≥ 44 g/day). Leisure-time physical activity was classified into four categories: almost every day, 2–4 times per week, once per week, and almost never. Sleep habits were classified into four categories: satisfied, slightly dissatisfied, quite dissatisfied, and very dissatisfied/have not slept at all.

Participants were also asked if they had experienced the triple disaster (yes/no). Triple disaster was defined as the Great East Japan Earthquake, tsunami, and subsequent Fukushima Daiichi nuclear disaster that occurred in Japan on March 11th, 2011. In the current study, experience of earthquake, tsunami, and Fukushima nuclear



accident was defined as feeling the shaking of the earth, evacuating or having the house and workplace destroyed by the tsunami, and hearing the sound of explosion of the Fukushima nuclear plant, respectively. Based on the questionnaire, 96.9% of the participants experienced the earthquake, 19.5% experienced the tsunami, and 53.4% experienced the Fukushima nuclear accident, explaining 99.4% answered yes at least one of the three disasters. We considered all of the participants to have experienced at least one of the three disasters, since all had been living in the 13 administrative districts at the onset of the triple disaster.

There were six options to describe participants' living arrangements at the time of the survey: evacuation shelter, temporary housing, rental housing, relatives' home, own home, and others. These were classified into two groups for analysis: 'evacuation' and 'no evacuation'. The 13 administrative districts recruited for this study have residents in the evacuation zone and in the non-evacuation zone. Therefore, the ones from the evacuation zone evacuated their home, while those from the non-evacuation zone chose to stay or evacuate their home. Therefore, at the time of this questionnaire, the ones living in their own house were all from the non-evacuation zone, but not from the evacuation zone. Postdisaster changes in participants' work situation were determined by a 'yes' or 'no' answer.

Laboratory data obtained from the participants included measures of aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma-glutamyl transpeptidase (γ -GT), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides (TG), fasting plasma glucose (FPG), and HbA1c. Diabetes was defined as FPG level ≥ 126 mg/dL, HbA1c level $\geq 6.5\%$, or self-reported use of antihyperglycemic agents. Hypertension was defined as systolic blood pressure >140 mm Hg, diastolic blood pressure >90 mm Hg, or self-reported use of antihypertensive agents. Dyslipidemia was defined as fasting LDL-C level ≥ 140 mg/dL, fasting TG level ≥ 150 mg/dL, fasting HDL-C level <40 mg/dL, or self-reported use of lipid-lowering agents. Height (in stocking feet) and weight (wearing light clothing) were measured in each participant. Body mass index (BMI) was calculated as weight (kg) divided by the square of the height (m^2); overweight was defined as BMI ≥ 25 kg/ m^2 . Chronic kidney disease was defined as an estimated glomerular filtration rate <60 mL/min/ 1.73 m 2 ¹⁵ and/or proteinuria (1+) measured using a dipstick urine test. Liver dysfunction was defined as AST ≥ 31 IU/L, ALT ≥ 31 IU/L, or γ -GT ≥ 51 IU/L.

Statistical analysis

Values are expressed as mean (SD), number (%), or median (IQR, 25%–75%). Group comparisons were evaluated using Fisher's exact tests for categorical variables and Mann-Whitney U test or t test for continuous variables. Participants were categorized into two (no diabetes mellitus and diabetes mellitus) or three (no

diabetes mellitus, diabetes mellitus with HbA1c $<7\%$, and diabetes mellitus with HbA1c $\geq 7\%$) categories. Crude, age-adjusted and sex-adjusted, and multivariate-adjusted logistic regression analyses were used to investigate the association between psychological distress (K6 ≥ 13) or probable PTSD (PCL-S score ≥ 44) and the other variables using estimated OR and 95% CI. In multivariate-adjusted logistic regression analysis, model 1 was adjusted for age, sex, diabetes mellitus, overweight, chronic kidney disease, smoker, alcohol intake, regular exercise, and evacuation. Model 2 consisted of model 1 parameters plus change of job. Model 3 consisted of model 1 parameters plus sleep dissatisfaction. Model 4 consisted of model 1 parameters plus change of job and sleep dissatisfaction. We selected covariates to explain psychological distress and PTSD from all measured items and questionnaire of the Fukushima Health Management Survey based on our previous results on these conditions^{3,14} Contingency coefficients of variables (Cramér's V) were calculated to estimate the mutual correlations of variables based on Pearson's χ^2 statistics and were considered as 0.1–0.29 for small effect size, 0.3–0.5 for medium effect size, and ≥ 0.5 for large effect size.¹⁶ All statistical analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA). All tests were two-sided; $p < 0.05$ was considered statistically significant.

RESULTS

General characteristics of participants

Among 16097 participants enrolled in the full analysis set, who had received medical and mental health surveys within a 2-month period between 6 and 12 months after the disaster, 7334 were in the medical health survey to mental health survey group and 8763 were in the mental health survey to medical health survey group (table 1). Mean age, proportion of participants ≥ 65 years old and male, anthropometry, blood measurements, comorbidities, and medications were all comparable between the two groups of participants. Smoking and drinking habit, sleep satisfaction, physical activity, and psychosocial factors were also comparable. In both groups, the group with diabetes was older, included more men, and had higher blood pressure, body weight, and BMI as compared with the group without diabetes. The prevalence of hypertension, dyslipidemia, overweight, chronic kidney disease, and liver dysfunction was also higher in the group with diabetes than in the group without diabetes, as were the frequencies of smoking and alcohol consumption. The sleep satisfaction trend tended to be bimodal (satisfied and very dissatisfied) in the group with diabetes. The frequency of participation in physical activities was higher in the group with diabetes than in the group without diabetes. The proportion of individuals who had been evacuated or experienced job changes was slightly lower in the group with diabetes than in the group without diabetes. The prevalence of psychological distress was comparable between the groups, but the

Table 1 General characteristics of participants

	Medical health survey to mental health survey						Mental health survey to medical health survey					
	Overall	Without diabetes mellitus		With diabetes mellitus		P value	Overall	Without diabetes mellitus		With diabetes mellitus		P value
		A1c <7.0%	A1c ≥7.0%	A1c <7.0%	A1c ≥7.0%			A1c <7.0%	A1c ≥7.0%			
n	7334	6501 (88.6)	314 (4.3)	519 (7.1)	314 (4.3)		8763	7776 (88.7)	639 (7.3)	348 (4.0)		
Age (years)	58.6 (9.3)	58.0 (9.4)	61.1 (8.2)	63.3 (7.0)	61.1 (8.2)	<0.001	58.3 (9.4)	57.7 (9.5)	63.3 (7.5)	60.9 (8.0)	<0.001	
>65 years old (%)	28.3	26.7	35.0	44.1	35.0	<0.001	27.8	26.1	46.0	32.8	<0.001	
Male sex (%)	45.2	42.8	62.7	64.6	62.7	<0.001	42.1	39.7	61.7	60.9	<0.001	
Anthropometry												
Systolic blood pressure (mm Hg)	130.3 (16.3)	129.6 (16.2)	135.3 (16.3)	136.3 (15.6)	135.3 (16.3)	<0.001	129.7 (16.3)	128.9 (16.2)	135.7 (15.1)	136.2 (15.5)	<0.001	
Diastolic blood pressure (mm Hg)	79.6 (10.5)	79.5 (10.5)	80.6 (10.9)	80.4 (10.2)	80.6 (10.9)	0.031	78.8 (10.4)	78.6 (10.5)	80.0 (9.9)	81.4 (10.4)	<0.001	
Body weight (kg)	60.8 (11.4)	60.2 (11.2)	66.2 (12.3)	65.7 (11.7)	66.2 (12.3)	<0.001	60.6 (60.6)	60.0 (11.2)	64.6 (11.2)	67.6 (12.9)	<0.001	
BMI (kg/m ²)	23.9 (3.5)	23.7 (3.4)	25.7 (3.8)	25.6 (3.7)	25.7 (3.8)	<0.001	23.9 (23.9)	23.6 (3.4)	25.3 (3.8)	26.1 (4.1)	<0.001	
Blood measurements												
A1c (%)	5.51 (0.76)	5.32 (0.36)	8.21 (1.26)	6.27 (0.43)	8.21 (1.26)	<0.001	5.53 (0.71)	5.35 (0.36)	6.31 (0.43)	8.07 (1.16)	<0.001	
A1c ≥7.0 (%)	4.3	0.0	100.0	0.0	100.0	<0.001	4.0	0.0	0.0	100.0	<0.001	
A1c ≥8.0 (%)	1.8	0.0	42.0	0.0	42.0	<0.001	1.6	0.0	0.0	39.1	<0.001	
FFPG (mg/dL)	97 (90, 105)	95 (90, 102)	165 (139, 200)	128 (116, 140)	165 (139, 200)	<0.001	96 (90,105)	95 (89, 101)	129 (115, 140)	159 (139, 187)	<0.001	
HDL cholesterol (mg/dL)	60.1 (15.4)	60.8 (15.4)	54.0 (14.3)	55.5 (14.9)	54.0 (14.3)	<0.001	61.1 (15.6)	61.7 (15.6)	57.2 (14.9)	55.4 (13.9)	<0.001	
LDL cholesterol (mg/dL)	127.4 (32.3)	127.8 (31.9)	126.7 (37.3)	122.5 (33.5)	126.7 (37.3)	0.002	128.7 (32.7)	129.3 (32.4)	121.5 (33.1)	128.9 (37.1)	<0.001	
Triglycerides (mg/dL)	97 (69, 139)	95 (67, 135)	126 (193, 287)	110 (79, 165)	126 (193, 287)	<0.001	97 (70, 140)	96 (69, 137)	108 (79, 153)	116 (82, 171)	<0.001	
Creatinine (mg/dL)	0.71 (0.62, 0.84)	0.71 (0.61, 0.83)	0.73 (0.62, 0.85)	0.78 (0.65, 0.90)	0.73 (0.62, 0.85)	<0.001	0.71 (0.62, 0.83)	0.70 (0.62, 0.83)	0.75 (0.63, 0.87)	0.74 (0.60, 0.84)	<0.001	
eGFR (mL/min/1.73m ²)	74.5 (13.5)	74.5 (13.0)	76.8 (15.6)	72.6 (17.4)	76.8 (15.6)	<0.001	74.3 (13.6)	74.2 (13.3)	73.3 (15.0)	77.3 (16.7)	<0.001	
Comorbidities												
Hypertension (%)	48.1	45.2	65.9	74.2	65.9	<0.001	46.6	43.8	69.9	67.2	<0.001	
Dyslipidemia (%)	57.5	55.7	77.3	68.8	77.3	<0.001	59.4	57.9	68.8	74.3	<0.001	
BMI ≥25.0 (%)	35.2	32.7	58.3	53.3	58.3	<0.001	34.2	32.0	47.9	57.8	<0.001	
Chronic kidney disease (%)	12.6	11.8	14.4	20.9	14.4	<0.001	14.7	14.0	19.8	21.5	<0.001	
Liver dysfunction (%)	32.9	30.8	54.5	44.9	54.5	<0.001	29.5	27.4	42.1	54.6	<0.001	
Medication												
Antidiabetic agents (%)	6.8	0.0	59.2	59.9	59.2	<0.001	6.6	0.0	57.4	60.1	<0.001	
Antihypertensive agents (%)	32.2	29.0	49.4	62.2	49.4	<0.001	31.3	28.6	55.4	48.1	<0.001	
Lipid-lowering agents (%)	17.2	15.2	32.6	33.1	32.6	<0.001	17.9	15.8	34.1	33.7	<0.001	

Continued



Table 1 Continued

	Medical health survey to mental health survey				Mental health survey to medical health survey			
	Overall	Without diabetes mellitus		P value	Overall	Without diabetes mellitus		P value
		A1c <7.0%	A1c ≥7.0%			A1c <7.0%	A1c ≥7.0%	
Smoking habit				<0.001				<0.001
Non-smoker (%)	58.4	60.2	43.5	46.0	59.6	61.4	45.1	46.2
Ex-smoker (%)	24.2	23.0	36.3	28.5	23.5	22.1	36.6	31.7
Current smoker (%)	17.5	16.8	20.2	25.6	16.9	16.5	18.3	22.1
Drinking habit				<0.001				0.003
Non-drinkers (%)	49.9	50.0	48.2	50.8	50.7	51.2	45.9	48.3
Drinkers <44 g/day (%)	39.3	39.7	36.4	34.8	38.8	38.6	39.3	40.5
Drinkers ≥44 g/day (%)	10.9	10.3	15.5	14.4	10.6	10.2	14.8	11.2
Sleep satisfaction				0.065				0.003
Satisfied (%)	34.5	34.0	39.4	36.6	34.7	34.1	41.9	36.0
A little dissatisfied (%)	46.3	46.6	45.5	42.0	46.0	46.5	42.1	42.4
Pretty dissatisfied (%)	15.5	15.8	11.0	16.8	15.5	15.6	11.6	18.5
Very dissatisfied (%)	3.7	3.6	4.0	4.6	3.8	3.8	4.4	3.0
Physical activity				<0.001				<0.001
Almost every day (%)	14.9	14.2	20.6	19.3	14.0	13.2	23.0	14.9
2–4 times a week (%)	20.9	20.3	28.2	21.2	20.5	20.0	26.3	21.0
Less than once a week (%)	15.5	15.4	16.5	15.1	14.2	14.2	13.5	14.9
Never (%)	48.7	50.1	34.6	44.4	51.4	52.7	37.2	49.3
Psychosocial factors								
Evacuation (%)	35.6	35.2	36.8	40.3	35.4	34.9	38.2	40.6
Change of job (%)	53.3	53.7	46.8	53.9	55.9	56.1	54.3	56.4
Psychological distress (K6 ≥13) (%)	13.5	13.5	11.2	17.2	13.3	13.2	13.0	14.4
Possible PTSD (PCL-S ≥44) (%)	19.9	19.7	19.3	24.2	19.2	19.0	20.7	21.0

Mean (SD), %, or median (IQR 25%, 75%). BMI, body mass index; eGFR, estimated glomerular filtration rate; FPG, fasting plasma glucose; HDL, high-density lipoprotein; K6, Kessler-6 Scale; LDL, low-density lipoprotein; PCL-S, PTSD Checklist-Stressor-Specific Version; PTSD, post-traumatic stress disorder.

prevalence of possible PTSD tended to be higher in the group with diabetes (table 1).

In the medical health survey to mental health survey group, there were 6501 participants without diabetes, 519 (7.1%) with diabetes with A1c <7.0%, and 314 (4.3%) with diabetes with A1c ≥7.0% (table 1). Participants with diabetes with A1c ≥7.0% were slightly younger and have slightly higher BMI than those in the A1c <7.0% group. The prevalence of dyslipidemia, overweight, and liver dysfunction was higher and for hypertension and chronic kidney disease was lower in participants with diabetes with A1c ≥7.0%. The frequencies of antihyperglycemic and lipid-lowering agents were comparable. The frequencies of current smoking and regular drinking were comparable between the two diabetes groups. The frequency of physical activity was lower in the A1c ≥ 7.0% group. The prevalence of psychological distress was higher was in the A1c ≥ 7.0% group and possible PTSD was comparable between the two diabetes groups.

In the mental health survey to medical health survey group (table 1), there were 7776 participants without diabetes, 639 (7.3%) with diabetes with A1c <7.0%, and 348 (4.0%) with diabetes with A1c ≥7.0%. The general characteristics of participants with A1c <7.0% or with A1c ≥7.0% were similar to those in the medical health survey to mental health survey group.

Logistic regression analysis

Medical health survey to mental health survey group

In the crude and age-adjusted and sex-adjusted logistic models (table 2), diabetes mellitus in two categories (no diabetes mellitus and diabetes mellitus) and diabetes mellitus with HbA1c <7% in three categories (no diabetes mellitus, diabetes mellitus with HbA1c <7%, and diabetes mellitus with HbA1c ≥7%) were not associated with psychological distress (K6 ≥13) or possible PTSD (PCL-S ≥44). In contrast, HbA1c ≥7% was associated with psychological distress and possible PTSD. In the multivariate-adjusted logistic models (table 3), HbA1c ≥7% was also associated with psychological distress, but not with possible PTSD, after adjusting for clinical (overweight, chronic kidney disease, smoking, alcohol intake, and physical activity) and disaster-related (evacuation, change of job, and sleep dissatisfaction) variables.

As a sensitivity analysis, we calculated the association between suboptimal diabetic control (HbA1c ≥7%) and psychological distress and possible PTSD in participants within a month interval between the two surveys (online supplemental tables S1–S3). The crude, age-adjusted and sex-adjusted, and multivariate-adjusted ORs for suboptimal diabetic control (HbA1c ≥7%) for K6 ≥13 or PCL-S ≥44 did not reach statistical difference.

Mental health survey to medical health survey group

In the crude and age-adjusted and sex-adjusted (table 2) and clinical and disaster-related variables-adjusted multiple logistic models (table 4), diabetes mellitus in two categories and diabetes mellitus in three categories

were not associated with psychological distress (K6 ≥13) nor possible PTSD (PCL-S ≥44).

Contingency coefficient of variables (Cramér's V) was calculated to detect potential association between two categorical variables. Although smoking and drinking showed a small correlation coefficient (0.280), no other medium and large correlations could be detected in other covariates (table 5).

DISCUSSION

This cross-sectional study evaluated the psychological distress, including non-specific mental health distress and possible PTSD symptoms, experienced by the Fukushima Health Management Survey participants with or without diabetes after the 2011 triple disaster. We observed two major findings. First, the presence or absence of diabetes mellitus was not significantly associated with non-specific mental health distress or possible PTSD. Second, suboptimal diabetic control (HbA1c ≥7%), irrespective of the presence of either untreated or treated diabetes, was associated with psychological distress, even after multivariate adjustment. This is the first report to show that suboptimal diabetic control is associated with non-specific mental health distress. This observation may support the contention that patients with diabetes, especially those with suboptimal diabetes control, may be vulnerable to psychological burden after a disaster, independent of psychosocial factors.

Diabetes mellitus and psychosocial reactions

Our study found that a diabetes diagnosis was not associated with non-specific mental health distress or possible PTSD symptoms. Nakaya *et al*⁶ reported that, among 43 487 community-dwelling people, those with diabetes demonstrated an OR of 1.3 for developing psychological stress, compared with those without diabetes (prevalence of 7.9% vs 5.3%, respectively; multivariate OR, 1.3; 95% CI 1.2 to 1.5; p<0.01). They also evaluated the prevalence of psychological distress, 1.5 years after the Great East Japan Earthquake and tsunami, in 3032 residents who had lived in the affected area. Their results, in agreement with the present results, indicated that diabetes mellitus was not associated with psychological distress, after multivariate adjustments for age, sex, smoking status, drinking status, walking, and income (patients with diabetes 6.9% vs patients without diabetes 5.1%; multivariate OR, 1.3; 95% CI 0.8 to 2.2; p=0.24).¹⁷ In contrast, the prevalence of psychological distress differed between the Nakaya *et al* study¹⁷ and ours (patients with diabetes 14.3% vs patients without diabetes 14.4%). The between-study difference in the prevalence of psychological distress might have arisen, at least in part, from the extent (double or triple) of the subject disaster and the evaluation period examined (within 1 year or longer). Based on these studies, the presence of diabetes mellitus might not be a strong stressor impacting the development of non-specific



Table 2 Logistic regression analysis of factors influencing psychological distress and PTSD after the disaster

Variables	Reference	OR for psychological distress (K6 ≥13)				OR for PTSD (PCL-S ≥44)							
		Crude		Sex-adjusted and age-adjusted		Crude		Sex-adjusted and age-adjusted					
		OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value			
Medical health survey to mental health survey (n=7334)													
Age	Per 1 SD	0.99	0.93 to -1.06	0.808	1.01	0.95 to -1.08	0.699	1.16	1.10 to -1.23	<0.001	1.18	1.12 to -1.26	<0.001
Men	Women	0.56	0.49 to -0.65	<0.001	0.56	0.49 to -0.64	<0.001	0.65	0.58 to -0.73	<0.001	0.63	0.56 to -0.71	<0.001
Diabetes mellitus (two categories)	No diabetes mellitus	0.999	0.81 to -1.23	0.991	1.13	0.91 to -1.40	0.277	1.09	0.91 to -1.30	0.332	1.12	0.93 to -1.34	0.230
Diabetes mellitus (three categories)													
A1c <7.0%	No diabetes mellitus	0.81	0.61 to -1.07	0.141	0.91	0.69 to -1.22	0.536	0.97	0.78 to -1.22	0.810	0.98	0.78 to -1.24	0.887
A1c ≥7.0%	No diabetes mellitus	1.34	0.99 to -1.81	0.060	1.50	1.11 to -2.04	0.009	1.30	0.998 to -1.70	0.052	1.36	1.04 to -1.78	0.026
A1c ≥7.0%	HbA1c <7.0%	1.36	1.00 to -1.83	0.048	1.51	1.12 to -2.05	0.008	1.30	0.998 to -1.70	0.050	1.36	1.04 to -1.78	0.025
Overweight (BMI ≥25)	No overweight	0.93	0.81 to -1.07	0.328	1.01	0.87 to -1.16	0.934	1.24	1.10 to -1.39	<0.001	1.30	1.15 to -1.47	<0.001
CKD	No CKD	0.99	0.80 to -1.21	0.890	1.02	0.82 to -1.26	0.877	1.16	0.98 to -1.37	0.093	1.07	0.90 to -1.27	0.451
Smoker													
Ex-smoker	Non-smoker	0.62	0.52 to -0.74	<0.001	0.90	0.72 to -1.12	0.331	0.72	0.62 to -0.84	<0.001	0.96	0.80 to -1.16	0.693
Current smoker	Non-smoker	0.79	0.65 to -0.95	0.014	1.08	0.87 to -1.35	0.472	0.82	0.70 to -0.96	0.016	1.14	0.95 to -1.38	0.162
Alcohol intake													
<44g/day	Non-drinker	0.70	0.61 to -0.82	<0.001	0.84	0.72 to -0.98	0.027	0.80	0.70 to -0.90	<0.001	0.95	0.83 to -1.08	0.437
≥44g/day	Non-drinker	0.71	0.56 to -0.90	0.005	1.02	0.79 to -1.33	0.879	0.79	0.65 to -0.97	0.021	1.09	0.88 to -1.36	0.424
Physical activity <4/week	Every day	1.22	1.00 to -1.49	0.050	1.17	0.95 to -1.44	0.130	1.11	0.94 to -1.31	0.226	1.18	0.997 to -1.40	0.054
Evacuation	No evacuation	1.71	1.49 to -1.96	<0.001	1.73	1.51 to -1.98	<0.001	1.69	1.51 to -1.90	<0.001	1.75	1.55 to -1.97	<0.001
Change of job	No change	2.12	1.83 to -2.45	<0.001	2.19	1.89 to -2.53	<0.001	2.16	1.91 to -2.44	<0.001	2.31	2.04 to -2.62	<0.001
Sleep dissatisfaction	No dissatisfaction	6.25	4.91 to -7.97	<0.001	6.01	4.72 to -7.67	<0.001	4.56	3.81 to -5.44	<0.001	4.66	3.89 to -5.58	<0.001
Mental health survey to medical health survey (n=8763)													
Age	Per 1 SD	1.02	0.96 to -1.09	0.489	1.05	0.98 to -1.11	0.161	1.15	1.09 to -1.21	<0.001	1.17	1.11 to -1.23	<0.001
Men	Women	0.65	0.57 to -0.74	<0.001	0.64	0.57 to -0.73	<0.001	0.73	0.65 to -0.81	<0.001	0.70	0.63 to -0.79	<0.001
Diabetes mellitus (two categories)	No diabetes mellitus	1.02	0.84 to -1.24	0.832	1.10	0.90 to -1.35	0.334	1.12	0.95 to -1.32	0.176	1.13	0.95 to -1.33	0.171
Diabetes mellitus (three categories)													
A1c <7.0%	No diabetes mellitus	0.98	0.77 to -1.24	0.861	1.05	0.83 to -1.35	0.673	1.11	0.91 to -1.36	0.297	1.10	0.90 to -1.35	0.346

Continued

Table 2 Continued

Variables	Reference	OR for psychological distress (K6 ≥13)						OR for PTSD (PCL-S ≥44)					
		Crude			Sex-adjusted and age-adjusted			Crude			Sex-adjusted and age-adjusted		
		OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
A1c ≥7.0%	No diabetes mellitus	1.10	0.81 to -1.50	0.542	1.19	0.88 to -1.63	0.262	1.13	0.87 to -1.48	0.351	1.17	0.89 to -1.52	0.261
A1c ≥7.0%	HbA1c <7.0%	1.10	0.81 to -1.50	0.534	1.19	0.87 to -1.62	0.274	1.13	0.86 to -1.46	0.383	1.15	0.88 to -1.51	0.292
Overweight (BMI ≥25)	No overweight	0.97	0.85 to -1.11	0.645	1.03	0.90 to -1.17	0.717	1.08	0.96 to -1.20	0.189	1.11	0.99 to -1.24	0.067
CKD	No CKD	1.06	0.88 to -1.27	0.545	1.05	0.87 to -1.27	0.591	1.28	1.10 to -1.49	0.001	1.19	1.02 to -1.39	0.030
Smoker													
Ex-smoker	Non-smoker	0.81	0.69 to -0.95	0.010	1.12	0.92 to -1.35	0.200	0.89	0.78 to -1.02	0.092	1.15	0.98 to -1.36	0.090
Current smoker	Non-smoker	0.86	0.73 to -1.03	0.105	1.16	0.95 to -1.42	0.153	0.88	0.76 to -1.03	0.102	1.19	0.999 to -1.42	0.052
Alcohol intake													
<44g/day	Non-drinker	0.81	0.71 to -0.92	0.002	0.94	0.81 to -1.09	0.396	0.84	0.75 to -0.94	0.003	0.96	0.85 to -1.09	0.560
≥44g/day	Non-drinker	0.90	0.73 to -1.11	0.304	1.20	0.95 to -1.52	0.127	0.95	0.79 to -1.14	0.560	1.24	1.02 to -1.52	0.033
Physical activity <4/week	Every day	1.12	0.93 to -1.34	0.249	1.10	0.91 to -1.33	0.307	1.04	0.89 to -1.22	0.627	1.11	0.95 to -1.30	0.198
Evacuation	No evacuation	1.59	1.40 to -1.80	<0.001	1.64	1.44 to -1.86	<0.001	1.52	1.36 to -1.70	<0.001	1.60	1.43 to -1.79	>0.001
Change of job	No change	2.08	1.81 to -2.38	<0.001	2.17	1.89 to -2.49	<0.001	2.12	1.88 to -2.38	<0.001	2.30	2.05 to -2.60	<0.001
Sleep dissatisfaction	No dissatisfaction	6.19	4.96 to -7.73	<0.001	6.07	4.86 to -7.59	<0.001	4.72	3.99 to -5.57	<0.001	4.83	4.08 to -5.71	<0.001

P values are two-tailed. BMI, body mass index; CKD, chronic kidney disease; HbA1c, hemoglobin A1c; K6, Kessler-6 Scale; PCL-S, PTSD Checklist-Stressor-Specific Version; PTSD, post-traumatic stress disorder.



Table 3 Multiple logistic regression analysis of factors influencing psychological distress and PTSD after the disaster: medical health survey to mental health survey group (n=7334)

	Model 1			Model 2			Model 3			Model 4		
	OR	95% CI	P value									
Psychological distress (K6 ≥13)												
Age	1.02	0.95 to -1.10	0.567	1.05	0.97 to -1.13	0.213	1.06	0.99 to -1.15	0.111	1.09	1.01 to -1.18	0.028
Men	0.61	0.50 to -0.74	<0.001	0.60	0.49 to -0.72	<0.001	0.70	0.57 to -0.85	<0.001	0.68	0.56 to -0.83	<0.001
Diabetes mellitus												
A1c <7.0%	0.90	0.67 to -1.20	0.476	0.94	0.70 to -1.26	0.689	0.90	0.67 to -1.21	0.490	0.95	0.70 to -1.27	0.708
A1c ≥7.0%	1.46	1.07 to -1.99	0.017	1.48	1.08 to -2.03	0.014	1.45	1.06 to -2.00	0.022	1.45	1.06 to -2.00	0.022
Overweight (BMI ≥25)	0.96	0.83 to -1.11	0.598	0.94	0.81 to -1.09	0.421	0.95	0.82 to -1.11	0.522	0.94	0.81 to -1.09	0.408
CKD	1.02	0.83 to -1.26	0.847	1.06	0.86 to -1.31	0.599	1.03	0.83 to -1.27	0.826	1.06	0.85 to -1.31	0.628
Smoker												
Ex-smoker	0.90	0.73 to -1.13	0.366	0.91	0.73 to -1.14	0.403	0.88	0.70 to -1.10	0.258	0.89	0.71 to -1.11	0.293
Current smoker	1.04	0.83 to -1.30	0.732	1.02	0.82 to -1.28	0.837	1.05	0.83 to -1.31	0.692	1.03	0.82 to -1.29	0.811
Alcohol intake												
<44 g/day	0.84	0.72 to -0.98	0.028	0.83	0.71 to -0.97	0.022	0.83	0.71 to -0.98	0.026	0.83	0.70 to -0.97	0.020
≥44 g/day	0.99	0.76 to -1.29	0.921	0.96	0.74 to -1.26	0.783	0.93	0.71 to -1.22	0.595	0.91	0.69 to -1.20	0.502
Physical activity <4/week	1.19	0.97 to -1.46	0.103	1.19	0.97 to -1.47	0.101	1.05	0.85 to -1.30	0.642	1.06	0.85 to -1.31	0.612
Evacuation	1.73	1.51 to -1.98	<0.001	1.49	1.30 to -1.72	<0.001	1.52	1.33 to -1.75	<0.001	1.35	1.17 to -1.55	<0.001
Change of job				2.00	1.72 to -2.33	<0.001				1.89	1.62 to -2.20	<0.001
Sleep dissatisfaction							5.67	4.44 to -7.24	<0.001	5.47	4.28 to -6.99	<0.001
PTSD (PCL-S ≥44)												
Age	1.20	1.13 to -1.29	<0.001	1.25	1.17 to -1.33	<0.001	1.26	1.18 to -1.35	<0.001	1.30	1.21 to -1.39	<0.001
Men	0.62	0.52 to -0.73	<0.001	0.60	0.51 to -0.71	<0.001	0.70	0.59 to -0.83	<0.001	0.68	0.57 to -0.81	<0.001
Diabetes mellitus												
A1c <7.0%	0.91	0.72 to -1.16	0.455	0.96	0.76 to -1.21	0.713	0.91	0.72 to -1.16	0.442	0.95	0.75 to -1.22	0.706
A1c ≥7.0%	1.24	0.94 to -1.63	0.123	1.26	0.95 to -1.66	0.104	1.23	0.93 to -1.63	0.153	1.23	0.93 to -1.64	0.149
Overweight (BMI ≥25)	1.26	1.11 to -1.42	<0.001	1.24	1.09 to -1.40	<0.001	1.26	1.12 to -1.43	<0.001	1.25	1.10 to -1.42	<0.001
CKD	1.07	0.90 to -1.27	0.470	1.11	0.93 to -1.33	0.244	1.08	0.90 to -1.29	0.404	1.12	0.93 to -1.34	0.231
Smoker												
Ex-smoker	0.95	0.79 to -1.14	0.600	0.96	0.80 to -1.16	0.697	0.93	0.77 to -1.12	0.458	0.94	0.78 to -1.14	0.542
Current smoker	1.11	0.91 to -1.34	0.303	1.09	0.90 to -1.32	0.377	1.12	0.92 to -1.36	0.249	1.10	0.91 to -1.34	0.330
Alcohol intake												
<44 g/day	0.95	0.83 to -1.09	0.472	0.95	0.83 to -1.08	0.417	0.95	0.83 to -1.09	0.443	0.94	0.82 to -1.08	0.389
≥44 g/day	1.07	0.85 to -1.34	0.579	1.04	0.83 to -1.31	0.725	1.02	0.81 to -1.28	0.898	0.996	0.79 to -1.26	0.974
Physical activity <4/week	1.18	0.99 to -1.40	0.063	1.18	0.99 to -1.40	0.062	1.05	0.88 to -1.26	0.577	1.06	0.88 to -1.26	0.557
Evacuation	1.73	1.54 to -1.95	<0.001	1.48	1.31 to -1.68	<0.001	1.54	1.36 to -1.73	<0.001	1.34	1.18 to -1.52	<0.001

Continued

Table 3 Continued

	Model 1			Model 2			Model 3			Model 4		
	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value	OR	95% CI	P value
Change of job	No change			2.11	1.86 to -2.40	<0.001	4.39	3.66 to -5.26	<0.001	2.02	1.77 to -2.30	<0.001
Sleep dissatisfaction	No dissatisfaction									4.26	3.55 to -5.11	<0.001

P values are two-tailed.
 Model 1: adjusted for age, sex, diabetes mellitus, overweight, CKD, smoker, alcohol intake, regular exercise, and evacuation.
 Model 2: model 1 plus change of job.
 Model 3: model 1 plus sleep dissatisfaction.
 Model 4: model 1 plus change of job and sleep dissatisfaction.
 BMI, body mass index; CKD, chronic kidney disease; K6, Kessler-6 Scale; PCL-S, PTSD Checklist-Stressor-Specific Version; PTSD, post-traumatic stress disorder.

mental health distress after a disaster or during a non-disaster, peacetime period.

HbA1c and psychosocial reactions

An HbA1c $\geq 7\%$ was strongly associated with psychological distress and possible PTSD. The current findings were consistent with previous reports. Neefs *et al*¹⁸ reported that anhedonia, but not depressed mood or anxiety, was associated with suboptimal glycemic control, reflected by an HbA1c $\geq 7\%$ (OR, 1.29; 95% CI 1.09 to 1.52) in 5772 primary care patients with type 2 diabetes mellitus in the Netherlands. Katon *et al*¹⁹ reported that the factors associated with depression in patients with diabetes mellitus include smoking, obesity, poor glycemic control (HbA1c $\geq 8\%$), and age < 65 years. In contrast, Ravona-Springer *et al*²⁰ reported that glycemic control variability (SD of a series of HbA1c determinations), but not mean HbA1c measurement, was associated with the number of subsequent depressive symptoms in elderly patients with type 2 diabetes in Israel (OR, per 1% HbA1c SD, 1.31; 95% CI 1.03 to 1.67; $p=0.03$). Although HbA1c levels were relatively well controlled in our study (mean, 6.95%; SD, 1.20%), HbA1c values $\geq 7\%$ remained associated with psychological distress, independent of other diabetes-related and psychosocial variables (eg, change of job, evacuation, and sleep dissatisfaction). Because the frequency of antidiabetic agent was comparable between individuals with HbA1c $< 7\%$ and HbA1c $\geq 7\%$, the non-achievement of optimal glycemic control may be associated with a psychological burden rather than with the presence of diabetes or diabetes treatment.

Notably, the association between suboptimal diabetic control (HbA1c $\geq 7\%$) and psychological distress was observed only in the medical health survey to mental health survey group, but not in the other group. Also, the association between suboptimal diabetic control (HbA1c $\geq 7\%$) and psychological distress was not significant in participants within a month interval between the two surveys. Since HbA1c is strongly correlated with mean glucose level over time at week 8, compared with week 4,⁹ this suggests that mean glucose level during 8 weeks could be associated with psychological distress. Combined, although we cannot discuss the cause and effect relationship between suboptimal diabetic control and psychological distress in the current study, the presence of HbA1c $\geq 7\%$ 2 months prior to assessment of psychological distress might be linked to psychological distress.

Potential mechanisms underlying the association between HbA1c and psychosocial reactions

The current study could not evaluate how anxiety is related to psychological burden in populations with diabetes. However, we could discuss three possible reasons.

First, people with diabetes with HbA1c $\geq 7.0\%$ may carry a large psychological burden that is associated with suboptimal glycemic control.²¹ The association



Table 4 Multiple logistic regression analysis of factors influencing psychological distress and PTSD after the disaster: mental health survey to medical health survey group (n=8763)

	Model 1			Model 2			Model 3			Model 4		
	OR	95% CI	P value									
Psychological distress (K6 ≥13)												
Age	1.07	1.00 to -1.15	0.046	1.11	1.03 to -1.19	0.004	1.11	1.03 to -1.19	0.004	1.14	1.06 to -1.22	<0.001
Men	0.62	0.52 to -0.74	<0.001	0.61	0.51 to -0.74	<0.001	0.71	0.59 to -0.85	<0.001	0.70	0.58 to -0.84	<0.001
Diabetes mellitus												
A1c <7.0%	1.01	0.79 to -1.30	0.917	1.01	0.79 to -1.29	0.958	1.05	0.82 to -1.35	0.704	1.04	0.80 to -1.34	0.782
A1c ≥7.0%	1.17	0.85 to -1.60	0.336	1.16	0.85 to -1.60	0.345	1.16	0.84 to -1.60	0.362	1.16	0.84 to -1.60	0.365
Overweight (BMI ≥25)	0.99	0.86 to -1.13	0.854	0.97	0.85 to -1.11	0.681	0.98	0.86 to -1.13	0.797	0.97	0.84 to -1.11	0.620
CKD	1.06	0.88 to -1.28	0.554	1.06	0.88 to -1.29	0.544	1.05	0.86 to -1.27	0.656	1.04	0.86 to -1.27	0.664
Smoker												
Ex-smoker	1.08	0.89 to -1.32	0.424	1.07	0.88 to -1.30	0.498	1.08	0.88 to -1.31	0.475	1.06	0.87 to -1.30	0.561
Current smoker	1.10	0.89 to -1.35	0.385	1.07	0.87 to -1.31	0.536	1.09	0.88 to -1.34	0.445	1.06	0.86 to -1.31	0.586
Alcohol intake												
<44 g/day	0.91	0.79 to -1.06	0.222	0.91	0.79 to -1.05	0.211	0.89	0.77 to -1.04	0.134	0.89	0.77 to -1.04	0.131
≥44 g/day	1.14	0.90 to -1.45	0.268	1.14	0.90 to -1.45	0.290	1.13	0.88 to -1.44	0.335	1.11	0.87 to -1.42	0.384
Physical activity <4/week	1.13	0.93 to -1.37	0.210	1.11	0.92 to -1.35	0.281	0.99	0.82 to -1.21	0.934	0.97	0.80 to -1.19	0.789
Evacuation	1.62	1.43 to -1.84	<0.001	1.43	1.25 to -1.63	<0.001	1.50	1.31 to -1.70	<0.001	1.35	1.18 to -1.54	<0.001
Change of job				1.98	1.72 to -2.29	<0.001				1.83	1.59 to -2.12	<0.001
Sleep dissatisfaction							5.82	4.66 to -7.28	<0.001	5.59	4.47 to -6.99	<0.001
PTSD (PCL-S ≥44)												
Age	1.20	1.13 to -1.27	<0.001	1.26	1.18 to -1.33	<0.001	1.25	1.17 to -1.32	<0.001	1.30	1.22 to -1.38	<0.001
Men	0.65	0.55 to -0.75	<0.001	0.63	0.54 to -0.74	<0.001	0.73	0.62 to -0.85	<0.001	0.72	0.61 to -0.84	<0.001
Diabetes mellitus												
A1c <7.0%	1.06	0.86 to -1.30	0.599	1.05	0.85 to -1.30	0.636	1.10	0.89 to -1.36	0.375	1.09	0.88 to -1.35	0.434
A1c ≥7.0%	1.11	0.85 to -1.46	0.438	1.11	0.85 to -1.46	0.447	1.11	0.84 to -1.46	0.475	1.11	0.84 to -1.46	0.477
Overweight (BMI ≥25)	1.07	0.95 to -1.20	0.247	1.05	0.94 to -1.18	0.378	1.07	0.95 to -1.20	0.259	1.05	0.93 to -1.19	0.403
CKD	1.19	1.02 to -1.39	0.031	1.20	1.02 to -1.40	0.028	1.18	1.01 to -1.39	0.044	1.18	1.01 to -1.40	0.043
Smoker												
Ex-smoker	1.11	0.94 to -1.31	0.228	1.10	0.93 to -1.30	0.269	1.10	0.93 to -1.31	0.267	1.09	0.92 to -1.29	0.324
Current smoker	1.13	0.95 to -1.36	0.171	1.11	0.92 to -1.32	0.274	1.13	0.94 to -1.36	0.194	1.10	0.92 to -1.33	0.297
Alcohol intake												
<44 g/day	0.94	0.83 to -1.06	0.314	0.94	0.82 to -1.06	0.298	0.92	0.81 to -1.05	0.204	0.92	0.81 to -1.05	0.199
≥44 g/day	1.19	0.97 to -1.46	0.098	1.18	0.96 to -1.45	0.116	1.18	0.96 to -1.45	0.128	1.16	0.94 to -1.43	0.161
Physical activity <4/week	1.14	0.97 to -1.33	0.125	1.12	0.95 to -1.31	0.191	1.00	0.85 to -1.18	0.972	0.98	0.83 to -1.16	0.853
Evacuation	1.57	1.41 to -1.76	<0.001	1.37	1.22 to -1.53	<0.001	1.45	1.30 to -1.63	<0.001	1.29	1.15 to -1.45	<0.001

Continued

Table 4 Continued

	Model 1		Model 2		Model 3		Model 4		
	OR	95%CI	P value	OR	95%CI	P value	OR	95%CI	P value
Change of job	No change			2.12	1.88 to -2.40	<0.001	1.99	1.75 to -2.25	<0.001
Sleep dissatisfaction	No dissatisfaction						4.45	3.76 to -5.28	<0.001

P values are two-tailed.
 Model 1: adjusted for age, sex, diabetes mellitus, overweight, CKD, smoker, alcohol intake, regular exercise, and evacuation.
 Model 2: model 1 plus change of job.
 Model 3: model 1 plus sleep dissatisfaction.
 *Model 4: model 1 plus change of job and sleep dissatisfaction.
 BMI, body mass index; CKD, chronic kidney disease; K6, Kessler-6 Scale; PCL-S, PTSD Checklist-Stressor-Specific Version; PTSD, post-traumatic stress disorder.

between suboptimal glycemic control and psychosocial reactions persisted after adjustment for potential clinical confounders such as age, sex, overweight, alcohol, smoking, and regular exercise. Of note, the association was yet observed corrected after yes or no of evacuation or change of job, which proved to be a strong stress to psychosocial reactions in the current participants,^{3 14} suggesting that other unmeasured psychological variables may play a mediating role. Place of living after a disaster can be a critical variable to psychosocial reactions. At the time of disaster, places of living such as evacuation shelters, temporary housing, rental housing, relatives' home, or own home are very important because these may influence psychological distress. Unfortunately, we could not obtain information on the current residence during the interview. Lifestyle factors such as physical activity, smoking, and alcohol drinking in different places of living may play a different effect and role. For example, people in an evacuation shelter will not have sufficient physical activities or will not smoke or drink as they wish, whereas people at their own home can. Sedentary lifestyle, no smoking, or no drinking will likely be more apparent among populations in evacuation shelters due to the presence of people who wish to be active, to smoke, or to drink but are unable to. In this sense, the variables smoking and drinking will work differently among places of living. Non-adherence to treatment may represent an important pathway between suboptimal diabetic control and emotional distress.²² Also, participants with diabetes with HbA1c $\geq 7.0\%$ could be more prone to consumption of palatable foods (eg, high-fat, high-sugar) and might be vulnerable to the effects of stress.²³

Second, health-related stigma might be related to the psychological burden after the triple disaster in people with diabetes. Diabetes stigma refers to the perception of negative feelings, such as exclusion, rejection, or blame for having diabetes; this has become a major problem for treatment of diabetes.²⁴ Kato *et al*²⁵ reported that higher levels of self-stigma and poorer patient self-care are related to suboptimal glycemic control in Japanese patients with type 2 diabetes mellitus. Self-stigma, including discrimination against workers and young women, medical history concealment, righteous anger, and loss of self-esteem, may have existed among the evacuees in the current study.³ Self-stigma alterations after the triple disaster may be linked to diabetes stigma. Specifically, diabetes stigma may be assumed to be linked to psychological burden via suboptimal glycemic control due to loss of self-esteem and/or poorer self-care among people with treated diabetes. This notion may be partially supported by the fact that the OR for possible PTSD was altered by adjusting for evacuation and sleep dissatisfaction.

Third, worsening glycemic control might reflect psychological burden after the disaster. Three months after the Great East Japan Earthquake, Fujihara *et al*²⁶ conducted a cross-sectional analysis, using the General

Table 5 Contingency coefficient of variables (Cramér's V)

	Diabetes mellitus	Overweight (BMI ≥25)	Chronic kidney disease	Current smoker	Alcohol intake ≥44 g/day	Physical activity <4/week	Evacuation	Change of job	Sleep dissatisfaction	Psychological distress	Post-traumatic stress disorder
Diabetes mellitus	–	0.146	0.064	0.072	0.034	0.014	0.018	0.022	0.043	0.014	0.017
Overweight (BMI ≥25)	0.146	–	0.070	0.088	0.034	0.027	0.037	0.028	–0.010	–0.008	0.024
Chronic kidney disease	0.064	0.070	–	0.071	0.045	–0.056	–0.018	–0.051	–0.021	0.005	0.021
Current smoker	0.072	0.088	0.071	–	0.280	0.074	0.044	0.066	0.067	0.042	0.039
Alcohol intake ≥44 g/day	0.034	0.034	0.045	0.280	–	0.015	0.034	0.046	0.048	0.064	0.057
Physical activity <4/week	0.057	0.027	–0.056	0.074	0.015	–	–0.018	0.027	0.101	0.022	0.009
Evacuation	0.018	0.037	–0.018	0.044	0.034	–0.018	–	0.236	0.115	0.095	0.103
Change of job	0.022	0.028	–0.051	0.066	0.046	0.027	0.236	–	0.117	0.112	0.141
Sleep dissatisfaction	0.043	–0.010	–0.021	0.067	0.048	0.101	0.115	0.117	–	0.211	0.236
Psychological distress	0.014	–0.008	0.005	0.042	0.064	0.022	0.095	0.112	0.211	–	0.537
Post-traumatic stress disorder	0.017	0.024	0.021	0.039	0.057	0.009	0.103	0.141	0.236	0.537	–

Contingency coefficients of variables (Cramér's V) were calculated based on Pearson's χ^2 statistics and were considered as 0.1–0.29 for small effect size, 0.3–0.5 for medium effect size, and ≥0.5 for large effect size.

BMI, body mass index.

Health Questionnaire, among patients with diabetes residing near the affected areas and found that physical symptoms (OR, 1.18; 95% CI 1.01 to 1.38) and sleep disorders or anxiety (OR, 1.26; 95% CI 1.08 to 1.46) were associated with worsening glycemic control. Thus, we may consider that a reversed cause and effect may be at play. However, the current study found that the prevalence of non-specific mental health distress was comparable between HbA1c <7% and HbA1c ≥7% groups in the mental health survey to medical health survey group, suggesting that non-specific mental health distress did not cause worsening glycemic control. The intervals for measurements (within 3 months of the disaster²⁶ vs over 6 months after the disaster in ours) may be linked to the discrepancy. The cause and effect relationship needs to be evaluated in future longitudinal studies.

Study limitations

Our research has some limitations. First, this was a cross-sectional observational study, necessitating confirmation of changes in K6 and PCL-S values in a longitudinal analysis. Second, we could not distinguish between type 1 and type 2 diabetes mellitus. Kondo *et al*²⁷ stated that there were no significant differences between the results of the Impact of Event Scale-Revised scores (quantifying traumatic reactions to the earthquake) between patients with type 1 and type 2 diabetes after the 2016 Kumamoto earthquake. However, Tanaka *et al*²⁸ reported that glycemic control in patients with diabetes and impaired endogenous insulin secretory capacity was vulnerable to change after the Great East Japan Earthquake. Also, the mean HbA1c level in our participants with diabetes (table 1) seems to be lower than in participants recruited at hospitals. It could be explained by the fact that our participants were recruited according to administrative districts and not by hospitals. This can limit our study results and interpretation. We need to carefully assess the factors associated with glycemic control and psychological burden in this study for comparisons with results across different populations and situations. Third, we could not conduct an analysis of places of living as a stratification. As discussed above, the place of living can be a critical variable to psychosocial reactions. Fourth, we could not assess the effects of radiation on psychological burden. Fifth, we studied the associations 6–12 months after the disaster and therefore we should be careful about interpretations of the effects of postdisaster circumstances. Finally, the current study could not evaluate how anxiety is related to psychological burden in populations with diabetes.

CONCLUSION

In conclusion, non-specific mental health distress and possible PTSD were associated with suboptimal diabetic control among evacuees impacted by the triple disaster. Patients with diabetes, especially those with suboptimal diabetic control, may be vulnerable to psychological

burden after a disaster, independent of disaster-related psychosocial factors.

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